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ABSTRACT

Two hypotheses proposed to explain the variance in second language tests are investigated. Hypothesis 1 (H1) claims that language skill is separable into components either related to linguistically defined categories (e.g., listening, speaking, reading, and writing). Another possibility (H2) is that second language ability may be a more unitary factor, so that once the common variance on a variety of language tasks is explained, essentially no meaningful unique variance attributable to separate components will remain. Previous studies have provided rather convincing support for H2. Data from 159 Iranian subjects at the University of Tehran, Iran who took a cloze test, a dictation, and the five subparts of the Test of English as a Foreign Language also support H2 in this report. However, when an oral interview task is included, the picture is less clear. Data from 106 foreign students (from mixed language backgrounds) at the Center for English as a Second Language at Southern Illinois University suggest the possibility of unique variances associated with separate skills. (Author/CFM)

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Two Mutually Exclusive Hypotheses about Second Language Ability: Factor Analytic Studies of a Variety of Language Tests[1]

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Abstract

Two hypotheses proposed to explain the variance in second language tests are investigated. Hypothesis 1 (H1) claims that language skill is separable into components either related to linguistically defined categories (e.g., phonology, syntax, and lexicon) or the traditionally recognized skills (i.e., listening, speaking, reading, and writing). Although tests of the presumed separable components are believed to produce substantial overlapping variances, it is assumed in H1 that tests aimed at a certain component (e.g., listening skill, or vocabulary knowledge) should also produce some meaningful variance that is unique to that component (i.e., not overlapping with variances of tests aimed at other components). Another possibility (H2) is that second language ability may be a more unitary factor such that once the common variance on a variety of language tasks is explained, essentially no meaningful unique variance attributable to separate components will remain. Previous studies have provided rather convincing support for H2 though it seems to be the less obvious of the two alternatives. Data from 159 Iranian subjects at the University of Tehran, Iran who took a cloze test, a dictation, and the five subparts of the Test of English as a Foreign Language also support H2 in this report. However, when an oral interview task is included, the picture is less clear. Data from 106 foreign students (from mixed language backgrounds) at the Center for English as a Second Language at Southern Illinois University suggest the possibility of unique variances associated with separate skills (though there is no evidence for the claim that there must be unique variances associated with components of grammatical knowledge, e.g. syntax versus phonology, vocabulary, etc.).

One of the empirical methods for investigating the composition of mental ability is to examine the pattern of intercorrelations between tests that purport to measure different aspects of that mental ability. Factor analysis is one of the statistical techniques for examining such patterns of correlation. In essence, it is a family of statistical procedures for studying the tendency of measures to produce meaningful variances, that is, variances which are either unique to a particular test or are common to two or more tests. All factoring methods aim to simplify the data available in a correlation matrix--the main question is how many factors and what sorts are required to explain essentially all of the variance in a given matrix? By variance we mean the algebraic quantity used in statistics to characterize the dispersion of scores about a mean score for a certain population of subjects on a certain test or battery of tests. By correlation we mean a similar quantity used to characterize the degree of overlap in variance, or the tendency for scores on separate tests to covary proportionately about their respective means.

The particular question investigated here is whether there is any unique variance associated with certain language processing tasks. For instance, is there any unique variance associated with tests that purport to measure vocabulary knowledge, for instance, as opposed to tests that purport to measure, say, syntactic knowledge? Or is there any unique variance associated with, say,

listening comprehension as opposed to speaking ability, for example, as judged by tests with those respective labels? In short, can language skill be partitioned into meaningful components which can be tested separately? Or, viewed the other way around, does variance in the performance of different language tasks support the componentialization of language competence?

Two mutually exclusive hypotheses have been offered. First there is what we will refer to as the divisible competence hypothesis: it has been argued by many linguists and pedagogues that language proficiency can be divided into separate components and separate skills or aspects of them. The components usually singled out include phonology, syntax, and lexicon and the skills listening, speaking, reading, and writing. Some have argued further that it is necessary to distinguish between receptive versus productive repertoires as well as auditory/articulatory versus visual/manual repertoires (that is, listening/speaking versus reading/writing). It has even been contended by Lado (1961), that the grammatical components posited for one skill or modality may be different from those functional in a different skill or modality. In a similar vein, Clark (1972) speaks of separate 'grammars' for speaking and listening.

A second major hypothesis is that language proficiency may be functionally rather unitary. The components of language competence, whatever they may be, may function more or less similarly in any language based task. If this were the case, high

correlations would be expected between valid language tests of all sorts. Seeming contradictory facts, such as the fact that listening comprehension usually exceeds speaking proficiency in either first or second language speakers, would have to be explained on some basis other than the postulation of separate grammars or components of competence. For instance, one might appeal to the load on attention and short term memory that is exerted by different language processing tasks. It may require more mental energy to speak than to listen, or to write than to read, and so forth.

If the variance associated with language tests which are aimed at separate components or skills were substantially overlapping (that is, if the tests were strongly correlated), the unitary competence hypothesis would be sustained. If unique variances could be associated with tests aimed at separate skills and/or separate components some version of the divisible competence hypothesis would be sustained.

The unitary competence hypothesis is reminiscent of Spearman's general factor of intelligence. In fact, Spearman (1904) invented factor analytic techniques explicitly for the purpose of testing for just such a general factor of intelligence. Oddly, though the construct of intelligence remains very poorly understood 72 years later, Spearman's general factor, according to a prominent Berkeley theorist, stands 'like a Rock of Gibraltar in

psychometrics, defying any attempt to construct a test of complex problem-solving which excludes it' (Jensen, 1972, 195). Our understanding of the nature of language competence has advanced more substantially than have theories of intelligence. We know much more explicitly what we mean by 'language proficiency' than we know about the meaning of 'intelligence.' Indeed, it is hardly questioned (though it has not been empirically demonstrated) that variance in language proficiency is probably the main portion of variance in tests of 'intelligence.'

Because Spearman's argument for a general factor of intelligence is similar to the unitary language competence hypothesis, it is possible to apply to the language question a statistical method devised as a test for a general factor of intelligence. Nunnally (1967) shows that if a general factor exists and is common to a variety of tests, the products of factor loadings on that general factor must predict the simple zero order correlations between the tests. That is, if a general (or unitary) factor exists the product of the loadings of any two tests on factor G (the general factor) will equal the raw correlation between those same tests. This follows from the general fact that for any factor matrix, the sum of products of loadings of any variables A and B on the respective factors must equal the correlation between A and B at least to the extent that the factor matrix exhausts the covariances in the original correlation matrix.

Therefore, the goodness of fit of the unitary hypothesis can be tested directly by factoring a variety of language tests to a principal components solution and then testing for a general factor by using the loadings on the first principal component to predict the original correlation matrix.

In this study, the above mentioned statistical test was applied to three sets of data. The first sample of data was from a population of 159 Iranians who took the five subparts of the Test of English as a Foreign Language (ETS) plus a cloze test, and a dictation. Subjects were students at the University of Tehran in Iran. All of the tests were administered with the help of the university and the American Field Service in 1972 and 1973. Results are presented in Tables 1-3.

Insert Tables 1-3 about here

Table 1 gives the loadings on a general factor as well as the squares of those loadings. The loadings, of course, may be interpreted as simple product moment correlations between the various test scores and the hypothetical variable which may be taken as an empirical estimate of a unitary language proficiency factor. It is in fact a linear combination of the original variables. The squared loadings indicate the proportion of variance overlap between the hypothetical factor defined by the principal components analysis

and any particular test variable. For instance, the Listening Comprehension subtest of the TOEFL correlates at .87 with the hypothetical G factor thus accounting for .76 (or 76%) of the variance in G; or alternatively, we may say that G accounts for 76% of the total variance in the Listening Comprehension section of the TOEFL.

The next step is to determine how well the general factor or unitary competence hypothesis accounts for the observed correlations between the various subtests used in the study. In other words, once the variance that can be attributed to G is partialed out, how much variance will remain? Will it be necessary to posit other factors in addition to G, or will the G factor suffice to explain essentially all of the non-error variance?

Table 2 presents in the upper half, correlations between test scores, and in the lower half the predicted correlations based on the respective products of loadings on G. Table 3 then presents the residuals--that is, what is left over after the products of loadings on G are subtracted (that is, partialed out). For instance, the product of loadings of Listening Comprehension and English Structure on the G factor is .71, while the actual correlation between the Listening Comprehension test and the English Structure test is .69. This leaves a residual of -.02. Proceeding in similar fashion for all variables, it soon becomes apparent from Table 3 that once the G factor is partialed out, practically no variance whatsoever remains to be explained.

Allowing for even a small percentage of error variance attributable to the unreliability and less than perfect validity of each of the various measures, there is essentially no variance left once G is removed. This is noteworthy for several reasons. In spite of the fact that there are two tasks that require listening to sequences of elements in English plus some indication of comprehension--namely, the Dictation, and the Listening Comprehension subsection of the TOEFL--no separate listening factor emerges. Similarly, in spite of the fact that there are several tests that require reading comprehension, vocabulary, and structure, no unique factors are needed to account for the variance in those tests, and neither do they produce any unique variances that can be associated with anything different from what is measured by the Cloze test or the Dictation.

A second set of data comes from foreign students at Southern Illinois University. No task that included the formulation of verbal sequences orally was included in the immediately foregoing study nor in the earlier work with the UCLA ESL Placement Exam (Oller, 1976). Hinofotis (1976), however, collected data from 106 subjects at SIU using the FSI Oral Interview with its five subscales along with a cloze test, and the three subparts of the Placement Examination used there by the Center for English as a Second Language. Results parallel to the ones given in Tables 1-3 above are presented in Tables 4-6 for this latter group of subjects and for the respective set of tests.

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Insert Tables 4-6 about here

The first of two factors in the principal components analysis accounts for 87% of the total variance in the factor matrix and receives no loadings less than 69% from any single test. The residuals in Table 6 are never as high as .20 and are always small in proportion to the observed correlations and the respective products of factor loadings.

The existence of a substantial general factor seems to be demonstrated, though the possibility remains that there is some unique variance that is associated with the FSI Oral Interview which is not also associated with the other tests used. A two factor explanation is supported by a varimax rotated orthogonal solution derived from the principal components analysis. The orthogonal solution is displayed in Table 7. The heaviest loadings on Factor 1 in Table 7 are from the subscales of the FSI Oral Interview while the heaviest loadings on Factor 2 are from the cloze, and CESL placement subtests. An oblique two factor solution (not displayed), however, revealed a .71 correlation between two similarly differentiated factors. Hence, the evidence for clearly distinct variance associated with a speaking factor is not completely convincing, but neither can it be ruled out. By comparing the eigen value associated with the two factor solution in Table 7 with the eigen value associated with the one factor solution in Table 4, it is possible to

form an impression of the advantage gained by the two factor solution over the one factor--about 13% of the total available variance is not accounted for by the G factor.

A third and final set of data comes from 51 of the above mentioned subjects who also took the TOEFL. The data from these subjects with the five TOEFL subtests included are given in Tables 8-10. In this case, the G factor accounts for only .65 of the total variance in the principal components matrix, while two additional factors are required to account for the remaining .35. The absolute mean of the residuals is .155 and has a range of .36 which is considerably larger than for either of the two previous populations. However, there is considerably less variance in the latter population on all tests. This is because the procedure for selecting the subjects to take the TOEFL eliminated roughly the bottom half of the distribution--i.e., no subject who placed below the middle of the distribution also took the TOEFL. Hence, the correlations in Table 9 for the 51 subjects are depressed as compared with the correlations in Table 5 for the full 106 subjects. For instance, whereas in Table 5 hardly any of the correlations are below .5, in Table 8 many are below .3.

Table 11 gives a varimax rotated solution for the 51 subjects over the 14 tests indicating three orthogonal factors which may tentatively be labelled "reading/graphic" (Factor 1, with .39 of the variance), "oral interview" (Factor 2, with .38 of the variance),

and "listening" (Factor 3, with .23 of the variance). The total eigen value for these three factors is 9.20 as compared with 7.94 in Table 8. Hence, the three factor solution accounts for 35% more variance than the single factor solution.

The results of this last analysis suggest the existence of a substantial G factor but suggest the possibility of unique variances associated with subtests aimed at separate skills (though not at separate components of skills). Further research will be necessary to determine whether factor 1 in Table 7 and 2 in Table 11 indeed constitute a "speaking" factor in the most general sense--i.e., whether such factors will have variances in common with other tests aimed at speaking ability (e.g., oral cloze, reading aloud, sentence repetition, etc.) but not also in common with tasks relying on other skills. Similarly, further research will be required to see if other tests that require listening comprehension will load on a factor such as 3 in Table 11 which is actually distinct from the possible speaking and graphic factors.

Insert Tables 8-11 about here

Considering the results of all three sets of data, the notion of separate components of structure, vocabulary, and phonology, finds no support. There is substantial evidence that the five subscales on the FSI Oral Interview, for instance, are equivalent.

The choice between the unitary competence hypothesis and the possibility of separate skills is less clear. There is some evidence to suggest that (excluding the oral interview data) if the data represent the whole range of subject variability, the unitary competence hypothesis may be the best explanation, but if the variability is somewhat less, a moderate version of a separate skills hypothesis would be preferred. Regarding the oral interview data, there seems to be some unique variance associated either with a separate speaking factor or with a judgemental factor related to the judges tendency to rate subjects consistently (a halo effect). Certainly there is substantial evidence that a general factor exists which accounts for .65 or more of the total variance in the several batteries of tests investigated.

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Notes

[1]A version of this paper was presented at the winter meeting of the Linguistic Society of America in Philadelphia, December 30, 1976.

[2]Oller is presently on leave from the University of New Mexico where he holds a position in Linguistics and Educational Foundations.

[3]Hinofotis, formerly an instructor in English at Southern Illinois University, has assumed a visiting appointment at UCLA in The Teaching of English as a Second Language.

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Table 1

Principal Components Solution (with iterations) for the Five Subtests of the Test of English as a Foreign Language, a Cloze Test, and a Dictation (N=159 Iranian subjects).

Tests	Loadings on G Factor*	h^2
Listening Comprehension	.87	.76
English Structure	.82	.67
Vocabulary	.67	.45
Reading Ability	.73	.53
Writing Ability	.78	.61
Cloze (any appropriate word scoring)	.87	.76
Dictation	.76	.58
	Eigen value	4.36

*Accounts for 100% of the total variance in the factor matrix.

Table 2

Correlation Matrix (above the diagonal) and Predicted Correlations Derived from Respective Products of Loadings on G (below the diagonal).

	1	2	3	4	5	6	7
1 Listening Comp		.69	.56	.64	.68	.76	.69
2 English Struct	.71		.64	.57	.65	.68	.63
3 Vocabulary	.58	.55		.49	.60	.51	.47
4 Reading Ability	.64	.60	.49		.58	.65	.53
5 Writing Ability	.68	.64	.52	.57		.67	.52
6 Cloze	.76	.71	.58	.64	.68		.75
7 Dictation	.66	.62	.51	.55	.59	.66	

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Table 3

Residual Matrix with G Loadings Partialed Out (mean of absolute values = .026, range = .08): Observed r minus Product of Loadings on G.

	1	2	3	4	5	6	7
1 Listening Comp		-.02	-.02	.00	.00	.00	.03
2 English Struct			-.08	-.03	.01	-.03	.01
3 Vocabulary				.00	.07	-.01	-.04
4 Reading Ability					.01	.01	-.02
5 Writing Ability						-.01	-.07
6 Cloze							-.08
7 Dictation							

Table 4

Principal Components Solution (with iterations) for the FSI Oral Interview Scales, the SIU CESL Placement Subtests, and a Cloze Test (N=106 subjects from mixed language backgrounds at SIU).

Tests	Loadings on G Factor*	h^2
Cloze	.81	.66
FSI Accent	.72	.52
FSI Grammar	.89	.79
FSI Vocabulary	.87	.76
FSI Fluency	.87	.76
FSI Comprehension	.86	.74
CESL Listening Comprehension	.78	.61
CESL Structure	.69	.48
CESL Reading	.76	.58
	Eigen value	5.90

*Accounts for 87% of the total variance.

Table 5

Correlation Matrix (above diagonal) and Predicted Correlations Derived from Respective Products of Loadings on G (below diagonal).

	1	2	3	4	5	6	7	8	9
1 Cloze		.51	.62	.55	.58	.58	.74	.69	.80
2 Accent	.58		.67	.65	.66	.68	.48	.55	.48
3 Grammar	.72	.64		.87	.85	.82	.64	.59	.53
4 Vocab	.70	.63	.77		.85	.84	.60	.48	.55
5 Fluency	.70	.63	.77	.76		.83	.63	.48	.51
6 Comp	.70	.62	.77	.75	.75		.58	.49	.53
7 CESL LC	.70	.56	.69	.68	.68	.67		.61	.74
8 CESL Str	.55	.50	.61	.60	.60	.59	.54		.63
9 CESL Rdg	.62	.54	.68	.66	.66	.65	.59	.52	

Table 6

Residual Matrix with G Loadings Partialed Out (mean of absolute values = .091, range = .17): Observed r minus Product of Loadings on G.

	1	2	3	4	5	6	7	8	9
1 Cloze		-.07	-.10	-.15	-.12	-.12	.04	.13	.18
2 Accent			.03	.02	.05	.04	-.08	-.05	-.06
3 Grammar				.10	.08	.04	-.05	-.02	-.15
4 Vocab					-.10	-.16	-.08	-.12	-.11
5 Fluency						.08	-.05	-.12	-.15
6 Comp							.09	-.10	-.12
7 CESL LC								.07	.15
8 CESL Str									-.11
9 CESL Rdg									

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Table 7

Varimax Rotated Factor Solution (with iterations) for a Cloze Test, the Five Subscales of the FSI Oral Interview, and the Three Subtests of the CESL Placement Examination (N=106 subjects at SIU).

Tests	Factor 1*	Factor 2**	h^2
1 Cloze	.34	.84	.83
2 FSI Accent	.63	.38	.54
3 FSI Grammar	.84	.40	.87
4 FSI Vocabulary	.86	.33	.85
5 FSI Fluency	.86	.34	.86
6 FSI Comprehension	.84	.34	.83
7 CESL Listening Comprehension	.42	.71	.68
8 CESL Structure	.34	.67	.57
9 CESL Reading	.28	.84	.79
		Eigen value	6.82

*Accounts for 56% of the total variance in the factor matrix.

**Accounts for 44% of the total variance in the factor matrix.

Table 8

Principal Components Solution (with iterations) for a Cloze Test, the Five Subscales on the FSI Oral Interview, the Three Subtests of the SIU CESL Placement Test, and the Five Subtests of the TOEFL (N=51 subjects from mixed native language backgrounds).

Tests	Loadings on G Factor*	h^2
Cloze	.80	.64
FSI Accent	.29	.08
FSI Grammar	.68	.46
FSI Vocabulary	.66	.44
FSI Fluency	.64	.41
FSI Comprehension	.65	.42
CESL Listening Comprehension	.76	.58
CESL Structure	.45	.20
CESL Reading Comprehension	.58	.34
TOEFL Listening Comprehension	.67	.45
TOEFL English Structure	.73	.53
TOEFL Vocabulary	.57	.32
TOEFL Reading Ability	.78	.61
TOEFL Writing Ability	.68	.46
	Eigen value	5.94

*Accounts for 65% of the total variance in the factor matrix.

Table 9

Correlation Matrix (above diagonal) and Predicted Correlations Derived from Respective Products of Loadings on G (below diagonal).

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Cloze		.07	.34	.28	.24	.28	.62	.51	.73	.52	.58	.64	.78	.64
2 FAc	.23		.56	.45	.53	.51	.05	.19	-.10	.05	.04	.02	.10	-.06
3 FGram	.54	.20		.80	.80	.79	.39	.19	.12	.31	.30	.23	.37	.28
4 FVoc	.53	.19	.44		.78	.75	.33	.13	.16	.35	.40	.29	.32	.29
5 FFlu	.51	.18	.44	.42		.77	.42	.00	.11	.44	.31	.20	.24	.20
6 FComp	.52	.19	.44	.43	.42		.42	.14	.26	.30	.29	.22	.36	.21
7 CLC	.61	.22	.52	.50	.49	.49		.26	.56	.74	.62	.40	.54	.56
8 CStr	.36	.13	.30	.30	.29	.29	.34		.25	.21	.59	.26	.50	.42
9 CRdg	.46	.17	.39	.38	.37	.38	.44	.26		.46	.44	.46	.55	.47
10 TLC	.54	.19	.46	.44	.43	.44	.51	.30	.39		.56	.25	.47	.51
11 TES	.58	.21	.50	.48	.47	.47	.55	.33	.42	.49		.40	.59	.72
12 TVoc	.46	.17	.39	.38	.36	.37	.43	.26	.33	.38	.42		.70	.44
13 TRdg	.62	.23	.53	.51	.50	.51	.59	.35	.45	.52	.57	.44		.61
14 TWrit	.54	.20	.46	.45	.44	.44	.52	.31	.39	.46	.50	.39	.53	

Table 10

Residual Matrix with G Loadings Partialed Out (mean of absolute values = .155, range = .36):

Observed r minus Product of Loadings on G.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Cloze		-.16	-.20	-.25	-.27	-.24	.01	.15	.27	-.02	.00	.18	.16	.10
2 FAc			.35	.26	.35	.32	-.17	.06	-.26	-.14	-.17	-.15	-.13	-.26
3 FGram				.36	.36	.36	-.13	-.11	-.27	-.15	-.20	-.16	-.16	-.18
4 FVoc					.36	.32	-.17	-.17	-.22	-.09	-.08	-.09	-.19	-.16
5 FFlu						.35	-.07	-.29	-.26	.01	-.16	-.16	-.26	-.24
6 FComp							-.07	-.15	-.12	-.14	-.18	-.15	-.15	-.23
7 CLC								-.08	.12	.23	.07	-.03	-.06	.04
8 CStr									-.01	-.09	.26	.00	.15	.11
9 CRdg										.07	.02	.13	.10	.08
10 TLC											.07	-.13	-.05	.05
11 TES												-.02	.02	.21
12 TVoc													.26	.05
13 TRdg														.08
14 TWrit														

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Table 11

Varimax Rotated Solution (with iterations) for a Cloze Test, the Five Subscales of the FSI Oral Interview, the Three Subtests of the SIU CESL Placement Examination, and the Five Subtests of the TOEFL (N=51).

Tests	Factor 1*	Factor 2**	Factor 3***	h^2
1 Cloze	.84	.12	.34	.84
2 FSI Accent	.03	.64	-.15	.43
3 FSI Grammar	.20	.89	.12	.84
4 FSI Vocabulary	.18	.81	.19	.73
5 FSI Fluency	.00	.87	.34	.88
6 FSI Comprehension	.17	.82	.19	.73
7 CESL Listening Comprehension	.41	.21	.75	.77
8 CESL Structure	.59	.07	.02	.35
9 CESL Reading	.56	-.01	.42	.49
10 TOEFL Listening Comprehension	.29	.19	.75	.68
11 TOEFL English Structure	.61	.17	.45	.60
12 TOEFL Vocabulary	.64	.12	.14	.44
13 TOEFL Reading Ability	.85	.19	.21	.80
14 TOEFL Writing Ability	.62	.07	.44	.57
			Eigen value	9.20

*Accounts for 39% of the total variance in the matrix.

**Accounts for 38% of the total variance in the matrix.

***Accounts for 23% of the total variance in the matrix.